INFLUENCE OF MINERAL ADMIXTURES ON EXPANSIVE SOIL

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Abstract - Expansive soils are known as shrink-swell soils which is highly plastic material which contains clay minerals such as Montmorillonite, Illite group which attracts and absorbs water that poses several challenges to civil engineers. They are considered a potential natural hazard, which can cause extensive damage to structures, if not treated. Such soils swell when given an access to water and shrink, when they dry out. In order to improve the characteristics of expansive soil, stabilization techniques were used. One of the most effective and economical method is addition of stabilizing agents such as lime or fly ash to expansive soil. Expansive soils always create problems more for lightly loaded structures than moderately loaded structures. By consolidating under load and changing volumetrically along with seasonal moisture variation, these problems are manifested through swelling, shrinkage and unequal settlement. In this study the experimental results obtained in the laboratory on expansive soils treated with low cost materials (lime and fly ash) are presented. A study is carried out to check the improvements in the properties of expansive soil with fly ash and lime in varying percentages. The test results such as Atterberg limit, standard proctor compaction, grain size analysis, hydrometer analysis, unconfined compressive strength and free swelling test obtained on expansive clays mixed at different percentages of lime and fly ash admixture are presented and discussed in this study. The expansive soil was stabilized with various percentages of lime i.e. at 2, 4, 6, 8, 10 and 12%, fly ash i.e. at 5, 10, 20, 30, 40 and 50% Fly ash possesses no plasticity. The results show that the stabilized clay has lesser swelling potential whereas increase in optimum moisture content has been observed.

Key Words: Expansive soil, Lime, Fly ash, Plasticity characteristics, Compaction characteristics, unconfined compressive strength.

1 INTRODUCTION

Expansive soil swell and shrink with change in water content and loose strength upon ingress of water. Excessive heave associated with swelling of expansive soil can cause considerable distress to light weight engineering structures. Several attempts have been made to control the swell-shrink behavior of these soils. There are several methods that have been used to minimize or eliminate the harmful effects of expansive/soft clayey soils on structures. The poor-quality soils usually have the potential to demonstrate undesirable engineering behavior, such as low load carrying capacity, high shrink and swell potential and high moisture susceptibility.

Expansive soils are normally associated with volumetric changes when subjected to changes in water content because of the seasonal water fluctuations. Furthermore, problems with clays, including low strength and high compressibility, can cause severe damage to civil engineering construction. Therefore, these soils must be treated before commencing the construction operation to achieve desired properties. Different methods are available to improve the engineering properties of problematic soils such as densification, chemical stabilization, reinforcement and techniques of pore water pressure reduction.

The present work is taken up is due to the above problems. The purpose was to check the scope of improving bearing capacity value and reduce expansiveness by adding additives. There are many methods of stabilizing soil to gain required engineering specifications. Soil stabilization method is one of the several methods of soil improvement. Different methods are mechanical stabilization, chemical stabilization etc. Most of these methods are relatively expensive to be implemented by slowly developing nations and the best way is to use locally available materials with relatively cheap costs affordable by their internal funds.

1.1 OBJECTIVE

The beneficial effects of this paper is to determine

- To study the effect of admixtures on expansive soil.
- To study the effect of flow, index and strength characteristic of soil.
- To study the improvement of index and shear strength properties on soft soil by mixing Fly ash at different percentages.
- To study the improvement of index and shear strength properties on soft soil by mixing lime at different percentages.
- To study the improvement of index and shear strength properties on soft soil by mixing combination of lime and fly ash at constant percentages.

2 REVIEW OF LITERATURE

B.R. Phanikumar, C. Amshumalini, R. Karthika (2009)[1] studied the expansive soil is used in the test program was collected from a depth of 1.2m below the ground level. The index properties of soil are tested. Unslaked lime was used as the additive. Lime content was varied as 0%, 2%, 4% and 6%. Swell potential and swelling pressure decreased with increase in lime content, but only up to 4% lime. Addition of lime beyond 4% resulted in increased swell potential and swelling pressure. Consolidation characteristics improved with increasing lime content as reflected in compression index, coefficient of consolidation and secondary consolidation. Compaction and strength characteristics improved up to 4% lime content.

S. Bhuvaneshwari, R. G. Robinson, S. R. Gandhi (2005)[2] studied the construction of an ash dyke at Ennore, chennai. This entire area is extensive shrinkage cracks exceeding 10mm width were noticed on the surface. The index properties of soil are tested in the fly ash contents of 0, 5, 10,15 and 20%.The ash blended expansive soil with fly ash contents of 0, 5, 10,15 and 20% on a dry weight basis and they inferred that increase in fly ash content reduces plasticity characteristics and the FSI was reduced by about 50% by the addition of 20% fly ash.

BairwaRamlakhan, Saxena Anil Kumar, Arora T.R (2013)[3] studied the Natural soil samples are taken from lakshminarain college, Bhopal. The soil sample is collected at a depth of depth of 2.5 m from ground level. Lime content varied from 3%, 6%, 9% and 12% and fly ash content varied from 10%, 20%, 30% and 40% with natural soil. CBR value of BC soil also increases with increasing varying % lime. The optimum percentage of lime at 12 % for gave the CBR value 5.6. CBR value of BC soil also increases with increasing varying % (lime + fly ash). The optimum percentage of mixture is (12%lime + 20% fly ash) which give the CBR value 7.99 that best result for sub grade soil.

BidulaBose (2012)[4] presents the study of high plastic commercial clay was stabilized using fly ash. Expansive soil was stabilized with various proportion of fly ash i.e. at 0, 20, 40, 60, 80, and 90 %. Fly ash possesses no plasticity. Fly ash has good potential for use in geotechnical applications. The relatively low unit weight of fly ash makes it well suited for placement over soft or low bearing strength soils. Its low specific gravity, freely draining nature, ease of compaction, insensitiveness to changes in moisture content, good frictional properties, etc. can be gainfully exploited in the construction of embankments, roads, reclamation of low-lying areas, fill behind retaining structures, etc.

Joseph Desire Muhirwa, Richard Benda, Robert Sargent, AravindPedarla, DrAnandPuppala [5] studied the soil sample from Austin, Texas, with a high plasticity index was used to study the effects of lime stabilization on expansive soils. The main goal was to increase the bearing capacity of the soil and reduce volumetric fluctuations of it.The expansive soil was stabilized with various proportion of lime i.e. at 0%, 2%, 4%, and 6%.We gained an understanding of the concepts behind lime stabilization. 6% lime provided the best results. However, 4% provided nearly similar results and could be more economical. 4% was determined to be the most effective additive for stabilization of Austin's expansive soil. For future research, lime could be combined with other additives (such as cement) for improved performance.

3 MATERIALS AND METHODS

3.1 MATERIALS

(a) Fly ash:

Fly ash is collected and its chemical constituents which were analyzed by XRF and the values are given in the Table 3.1.

Table 3.1 Chemical constituents of fly ash

Chemical Constituents	**Percentage**
SiO_2	40.660
Al_2O_3	36.44
Fe_2O_3	2.853
CaO	10.37
SO_3	3.463
MgO	2.760
TiO_2	2.210

(b) Soil:

Expansive soil is taken from Krishna Nagar, Puducherry region from a depth of 1.2 m below the ground level. The soil was air dried and pulverized manually. Expansive soil has the swelling and shrinkage properties changes in the moisture content. This expansive soil is grey to black in color. Basic properties of the expansive soil used in experiment work are presented in table 3.2.

Table 3.2 Properties of the soil

Sl. No.	**Description**		**Unit**	**Results**
1.	Grain size analysis	<75	µ	83.44
		>75	µ	16.56
2.	Hydrometer analysis	Clay	%	12
		Silt	%	88
3.	Atterberg limit	LL	%	55
		PL	%	29.15
		PI	%	25.85
		SL	%	3.89
4.	UCC		kPa	28.76
5.	Compaction	OMC	%	23.4
		MDD	kN/m^3	15.85
6.	Free swell			40
7.	pH value test			6.37

(c) Lime:

Lime is collected and its chemical properties are given in the following Table 3.3.

Table 3.3 Chemical constituents of lime

Chemical Constituents	**Percentage**
$CaCO_3$	≥98.5
SO_4	≤0.5
Pb	≤0.005

3.3 EXPERIMENTAL SETUP

Fly ash is mixed in varying percentage of 5%, 10%, 20%, 30% 40% and 50% with expansive soil and lime are mixed in varying percentage of 2%, 4%, 6%, 8%, 10% and 12% with expansive soil.

3.4 ANALYTICAL METHODS FOR SOIL CHARACTERIZATION

Following are the tests conducted for the soil samples collected from the site:

i) Atterberg limits (Liquid Limit, Plastic Limit and Shrinkage Limit)
ii) Hydrometer analysis
iii) Standard proctor compaction test
iv) Unconfined compressive strength and
v) pH value test
vi) Free swell index

Table 3.4 IS Classification based on liquid limit (IS 1498)

Liquid limit	**Description**
Less than 35%	Low compressibility
35% -50%	Medium compressibility
Greater than 50%	High compressibility

Table 3.5 IS Classification based on the plasticity index (IS 1498)

Plasticity index	**Soil description**
0	Non plastic
Less than 7	Low plastic
7-17	Medium plastic
Greater than 7	Highly plastic

4 RESULTS AND DISCUSSION

4.1 EFFECTS OF FLY ASH ON ATTERBERGS LIMIT

Table 4.1.1 effects of fly ash on atterbergs limit

Lime mixture (%)	**Liquid limit (%)**	**Plastic limit (%)**	**Shrinkage limit (%)**	**Plasticity index (%)**
0	55	29.15	3.89	25.85
5	48	24.8	12.47	23.2
10	48.5	26.13	13.82	22.37
20	52.5	31.95	18.23	20.55
30	54	23.83	16.75	30.17
40	NA	28.97	21.02	NA
50	NA	22.84	21.0	NA

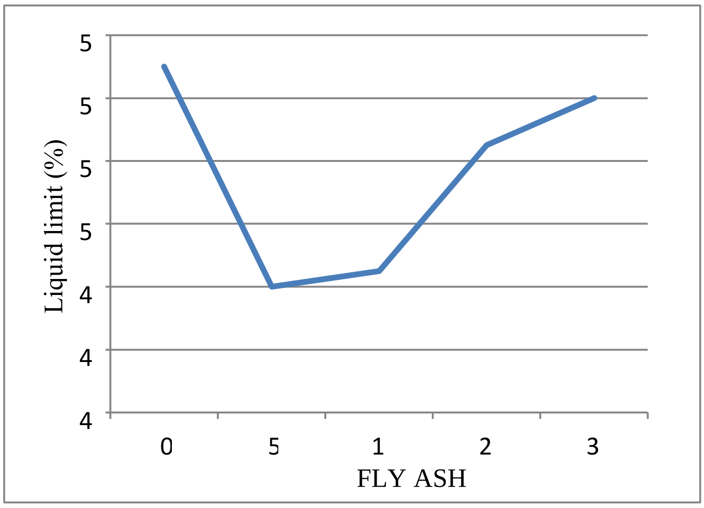

Fig 4.1.1 Effect of fly ash on Liquid limit

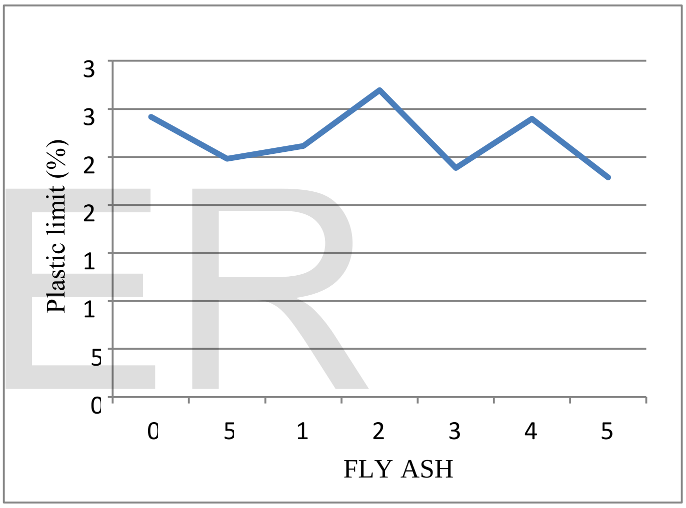

Fig 4.1.2 Effect of fly ash on Plastic limit

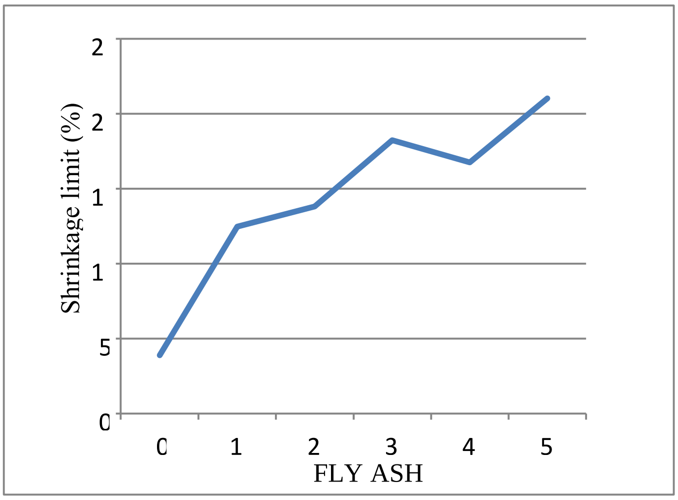

Fig 4.1.3 Effect of fly ash on Shrinkage limit

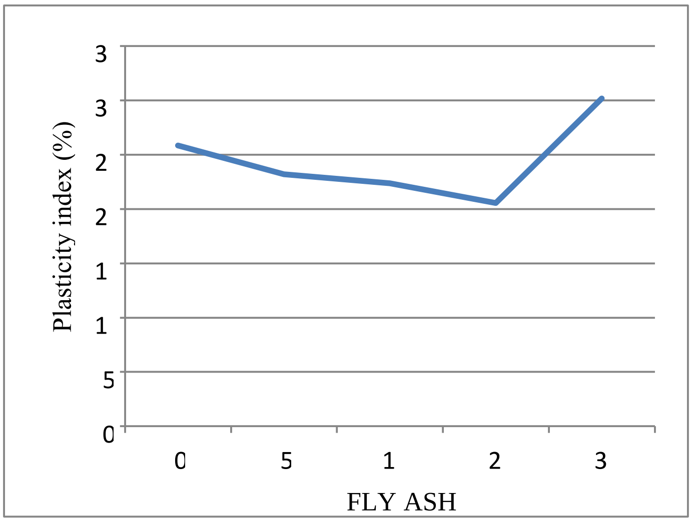

Fig 4.1.4 Effect of fly ash on Plasticity index

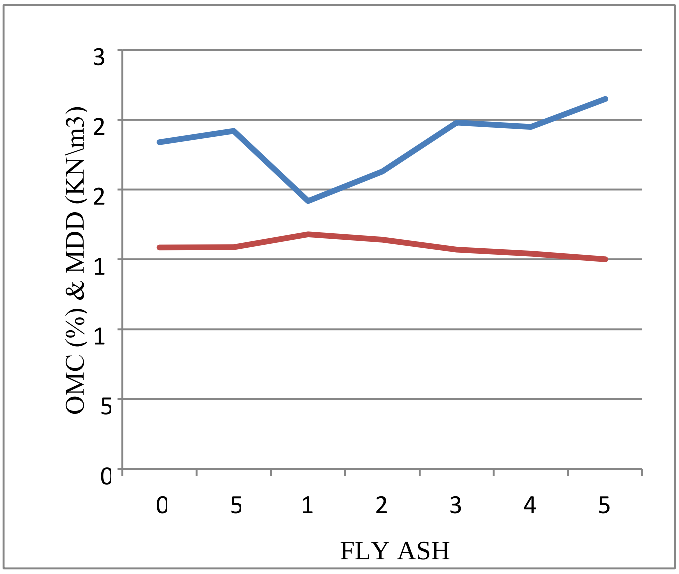

Fig 4.2.1 Effect of fly ash on Compaction

4.2 EFFECT OF FLY ASH ON COMPACTION PARAMETERS

Table 4.2.1 Effect of fly ash on Compaction Parameters on soil

Lime mixture (%)	**Compaction parameters**	
	OMC (%)	**MDD (KN/m³)**
0	23.4	15.85
5	24.20	15.87
10	19.2	16.8
20	21.3	16.41
30	24.8	15.7
40	24.5	15.4
50	26.5	15.0

4.3 EFFECT OF FLY ASH ON UNCONFINED COMPRESSIVE STRENGTH

Table 4.3.1 Effect of fly ash on Unconfined Compressive Strength (UCC)

Lime mixture (%)	**UCC value in kPa**
0	28.76
5	43
10	40.5
20	14.5
30	17
40	15
50	14.25

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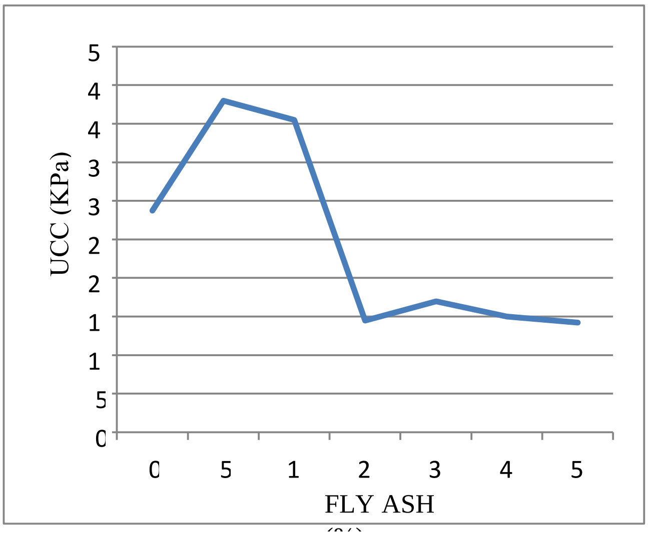

Fig 4.3.1 Effect of fly ash on UCC

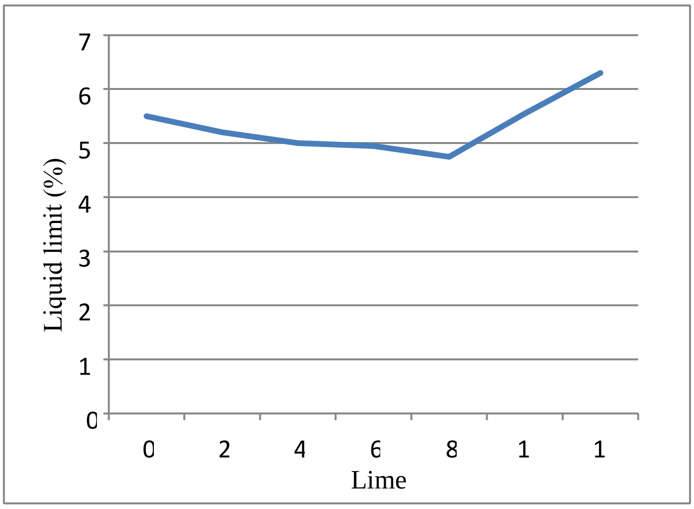

Fig 4.4.1Effect of lime on Liquid limit

4.4 EFFECT OF LIME ON ATTERBERGS LIMIT

Table 4.4.1 Effect of lime on Atterberg limits on expansive soil

Lime mixture (%)	Liquid limit (%)	Plastic limit (%)	Shrinkage limit (%)	Plasticity index (%)
0	55	29.15	3.89	25.85
2	52	24.42	12.5	27.58
4	50	28.39	13.67	21.61
6	49.5	25.31	10.35	23.89
8	47.5	17.24	8.51	30.26
10	55.5	25.7	12.35	29.8
12	63	27.89	6.75	35.11

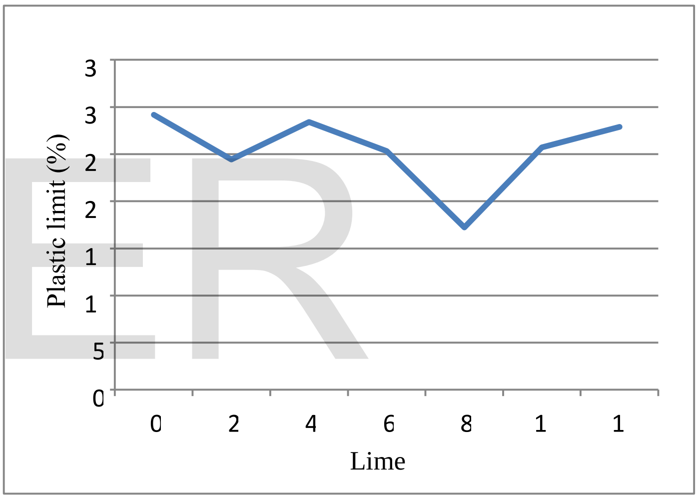

Fig 4.4.2Effect of lime on Plastic limit

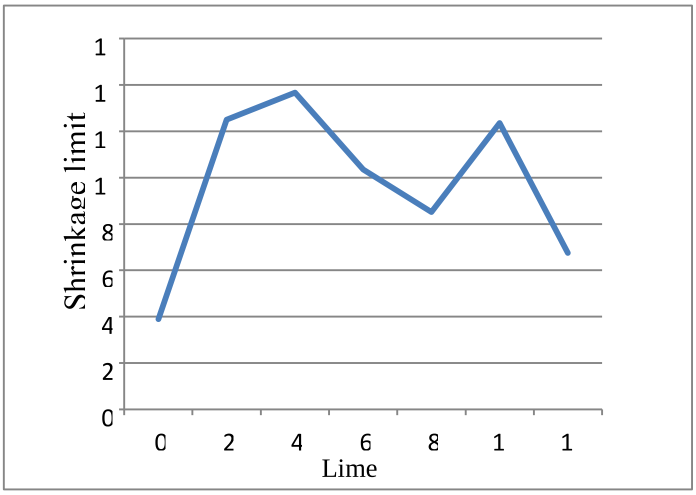

Fig 4.4.3 Effect of lime Shrinkage limit

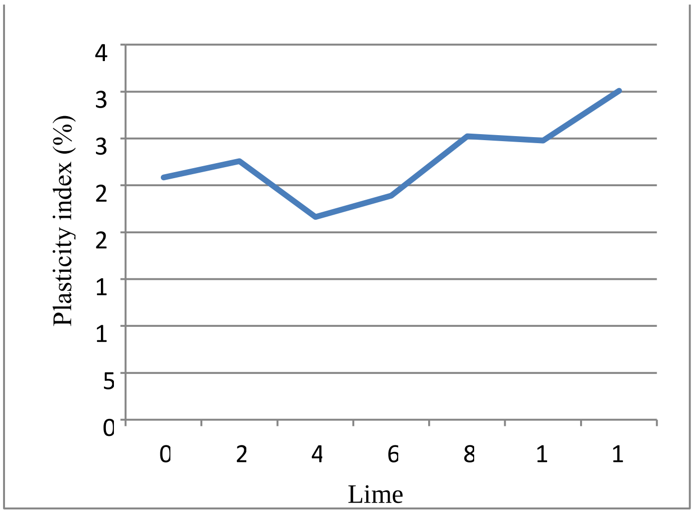

Fig 4.10 Effect of lime on Plasticity index

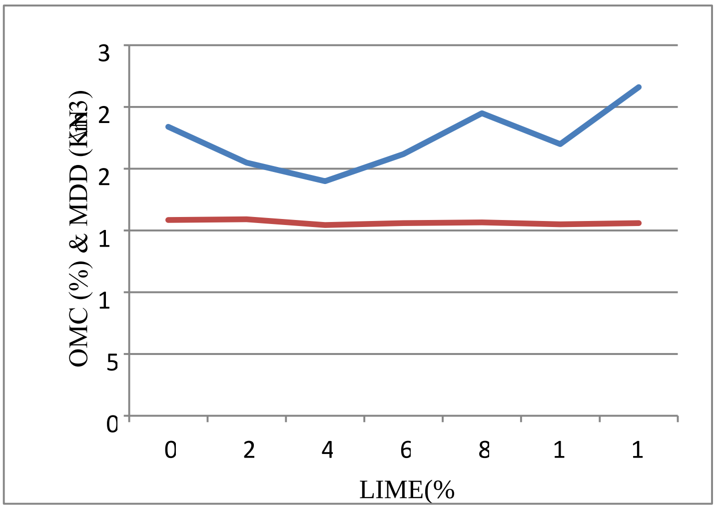

Fig 4.5.1 Effect of lime on compaction

4.5 EFFECT OF LIME ON COMPACTION PARAMETERS

Table 4.5.1 Effect of lime on Compaction Parameters on soil

Lime mixture (%)	**Compaction parameters**	
	OMC (%)	**MDD (KN/m³)**
0	23.4	15.85
2	20.56	15.9
4	19.0	15.45
6	21.2	15.6
8	24.5	15.65
10	22.0	15.50
12	26.6	15.6

4.6 EFFECT OF LIME ON UNCONFINED COMPRESSIVE STRENGTH

Table 4.6.1 Effect of lime on Unconfined Compressive Strength (UCC)

Lime mixture (%)	**UCC value in kPa**
0	28.76
2	46.87
4	44.12
6	45.37
8	46.88
10	48.23
12	50.29

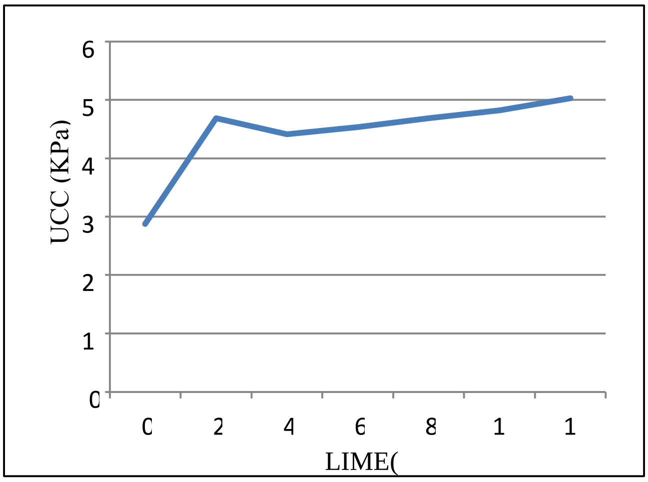

Fig 4.12 Effect of lime on Ucc

5 CONCLUSION

Table 5.1 Effect of lime and fly ash for soil properties

Description	Unit	Result
Liquid Limit	%	60.05
Plastic Limit	%	29.16
Shrinkage Limit	%	12.71
Plasticity Index	%	30.89
OMC	%	24.9
MDD	kN/m^3	15.84
UCC	kPa	51.75

5.1 CONCLUDING REMARKS

Based on the results and discussions presented in the Chapter 4, the following conclusions are drawn:

- It was showed that the liquid limit was decreased from 55% to 48% with the increased concentration of fly ash during the experiment.
- The plastic limit value is increased gradually with the addition of fly ash and obtains maximum values at 20% of fly ash and decreased gradually further adding fly ash content.
- The shrinkage limit is increased gradually with the addition of fly ash.
- The increment in OMC and decrement in MDD on expansive soil stabilized by

  fly ash.
- The overall results shows that the liquid limit is increased gradually with addition of fly ash at various percentages and simultaneously the maximum dry density value decreased. And satisfactory results are obtained while adding 10% of fly ash.
- It was showed that the liquid limit was decreased from 55% to 47.5% with the increased concentration of lime during the experiment.
- The plastic limit and shrinkage limit value is decreased gradually with the addition of lime and obtains maximum values at 8% of lime.
- The increment in OMC and decrement in MDD on expansive soil stabilized by lime.
- The addition of lime to the expansive soil showed marked decrement in liquid limit and reasonable increasing plastic limit, over all addition of lime showing good reduction in plasticity index of soils.

REFERENCES

Phanikumar. B.R., Amshumalini C., Karthika .R., (2009), Effect of lime on engineering behavior of expansive soil. IGC , Gunter, India.
Ravi Kumar Sharma. Dr., (2013), Effect of waste tube rubber chips on compaction, sub grade and drainage characteristics of clay mixed with sand and fly ash. The Clute Institute International Academic Conference.
Bidula Bose., (2012), Geo-Engineering Properties of Expansive Soil Stabilized with Fly Ash. EJGE.
EmillianiAnakGeliga., Dygku Salma Awg Ismail., (2010), Geotechnical Properties of Fly Ash and its Application on Soft Soil Stabilization. UNIMAS E-Journal of Civil Engineering.

Neeraja D., (2010), Influence of Lime and Plastic Jute on Strength and CBR Characteristics of Soft Clayey (Expansive) Soil. Influence of Lime and Plastic Jute on Strength and CBR Characteristics of Soft Clayey (Expansive) Soil.

Joseph Desire Muhirwa., Richard Benda., Robert Sargent., AravindPedarla., Dr. AnandPuppala., Lime Stabilization of Expansive Soils. University of TEXAS Arlington.

Neeraj Kumar Sharma., S. K. Swain Umesh C., Sahoo., (2012), Stabilization of a Clayey Soil with Fly Ash and Lime: A Micro Level Investigation. Geotechnical and Geological Engineering An International Journal.

OmidAzadegan., AkbariKaffash E., Yaghoubi M.J., Pourebrahim G.R., (2012), Laboratory Study on the Swelling, Cracking and Mechanical Characteristics of the Palm Fiber Reinforced Clay. EJGE.

Karthik.S., Ashok kumar.E., Gowtham.P., Elango.G., Gokul.D., Thangaraj.S., (2014), Soil Stabilization By Using Fly Ash. IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE).

Monica Malhotra., Sanjeev Naval., (2013), Stabilization of Expansive Soils Using Low Cost Materials. International Journal of Engineering and Innovative Technology (IJEIT).

A shish Mehta., KanakParate ., B. S. Ruprai., (2013), Stabilization of black cotton soil by Fly Ash. International Journal of Application or Innovation in Engineering & Management (IJAIEM).

Monica Malhotra., Sanjeev Naval., (2013), Stabilization of Expansive Soils Using Low Cost Materials. International Journal of Engineering and Innovative Technology (IJEIT).

BairwaRamlakhan., Saxena Anil Kumar., Arora T.R., (2013), Effect of lime and fly ash on Engineering Properties of Black Cotton soil International Journal of Emerging Technology and Advanced Engineering (IJETAE).

Ramu K.,DayakarBabu R., Harikishore V., Raviteja K.V.N.S., Lavanya P.M., (2013), Strength behavior of WTR reinforced lime-fly ash-expansive soil mixes. Proceedings of Indian Geotechnical Conference.

AsmaMuhmed., DariuszWanatowski., (2013), Effect of Lime Stabilization on the Strength and Microstructure of Clay. IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE).

Basavanna., B.M. and Itagi Ravi Kumar (1990), „ Use of Coal Ash to Improve Some Properties of Black Cotton Soil,“ Indian Geotechnical Confrence-1990 on Advances in Geotechnical Engineering, Indian Geotechnical Society, Bombay, India, pp. 185 – 188.

Das., B.M., (2002), Principles of Geotechnical Engineering, Fifth Edition, Australia; Brooks/Cole.

Ferguson. G., (1993), "Use of self-cementing fly ashes as a soil stabilization agent." Fly ash for soil improvement, Geotechnical Special Publication *No. 36*, ASCE, New York, 1–14.

Ferguson. G., (1990), Aggregate Bases Constructed with Self Cementing Fly Ash, 9th international Ash Utilization Symposium, Washington, D.C.

Ferguson. G.,(1987), Ferguson. G (1987), Aggregate Bases Constructed with Self Cementing Fly Ash, 8th international Ash Utilization Symposium, Washington, D.C.

FHWA., 2006, FHWA., (2006), – US Department of Transportation, Federal Highway Administration, Chapter 1 - Fly Ash Facts for Highway Engineers - Recycling – Pavements.

Gray.,Lin., 1972, Gray., D.H., and Lin., Y.K., (1972), „Engineering Properties of Compacted Fly Ash."Journal Soil Mechanics Foundation Engineering, ASCE, Vol. 98, pp.361-380.